ENTRIX DRAFT

REVISED DRAFT SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT WORK PLAN FOR THE TITTABAWASSEE RIVER AND ASSOCIATED FLOODPLAINS

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Definitions and Acronyms

ADD_{pot}	Potential average daily dose
ATL	Aquatic Toxicology Laboratory
BERA	Baseline ecological risk assessment
COPECs	Chemicals of potential ecological concern
DQOs	Data quality objectives
EEC	Estimated exposure concentration
ERA	Ecological risk assessment
FCMP	Fish containment monitoring program
HQ	Hazard quotient
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MSU	Michigan State University
NPDES	National pollutant discharge elimination system
PBBs	Polybrominated biphenyls
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo-*p*-dioxins
PCDFs	Polychlorinated dibenzofurans
RI	Remedial investigation
SLERA	Screening-level ERA
SMDP	Scientific management decision point
Eco-SSL	Soil screening levels
TRV	Toxicity reference value
UF	Uncertainty factor
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United State Geological Survey
VOCs	Volatile organic compounds
WHO	World Health Organization

1.0 INTRODUCTION

As specified by USEPA guidance, the first step in the ecological risk assessment (ERA) process is a screening-level (SLERA) or Tier I ERA in which the objective is to identify and document conditions that do *not* warrant further evaluation in a more refined baseline ERA (BERA). The goal is to eliminate insignificant hazards while identifying contaminants whose concentrations are sufficiently great as to potentially pose risks to ecological receptors. As defined by the USEPA, a SLERA is a simplified risk assessment that can be conducted with limited data where site-specific information is lacking and assumed values are used to evaluate potential exposure and effects (USEPA 1997). For a SLERA, it is important to minimize the chances of concluding that there is no risk when in fact a risk exists, i.e., the technique assures that β is minimized and the probability of a Type II error (false negative) is very low. Thus, for exposure and toxicity or effect parameters for which site-specific information is minimal, assumed values, such as area-use and bioavailability, should be consistently biased in the direction of overestimating risk. This ensures that sites that might pose an ecological risk are studied further, i.e., a SLERA is deliberately designed to be protective in nature, not predictive of effects. It is important to note that SLERAs are neither designed nor intended "to provide definitive estimates of actual risk, generate cleanup goals, and in general, are not based upon site-specific assumptions" (USEPA, 2001a). If any potentially significant exposure pathways are indicated from the SLERA, then these pathways are further evaluated in a more refined BERA.

Previously, two preliminary ERAs were performed for the Tittabawassee River and its floodplain focusing on the aquatic environment (GES 2003) and the terrestrial environment (GES 2004) and their associated food chains. Based on these analyses, it is appropriate to conclude that polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) will continue to be COPECs and are currently the focus of ongoing studies that will be used in the BERA. The Work Plan presented here outlines the framework for a SLERA that will include an analysis of currently available data in order to identify other Contaminants of Potential Ecological Concern (COPECs) in the Tittabawassee River sediments and associated floodplain soils. As additional COPECs are identified, the potential ecological risks associated with each COPEC will be further evaluated and characterized.

1.1 Purpose and Scope

The overall purpose of this SLERA Work Plan is to present a detailed approach for conducting a SLERA for the Tittabawassee River and associated floodplains, hereafter referred to as the "Site". This SLERA Work Plan was developed in partial fulfillment of the conditions stated in the Hazardous Waste Management Facility Operating License, which was issued on June 12, 2003 by Michigan Department of Environmental Quality (MDEQ) to The Dow Chemical Company (Dow). While the scope of the current SLERA evaluations are confined to the Tittabawassee River and its floodplain, the approaches and methodologies outlined in this work plan can be used to evaluate other potential COPECs that may be present down river of the confluence of the Tittabawassee and the Saginaw Rivers. ENTRIX, Inc. and CH2MHill, as specified in this Work Plan, will conduct supplemental investigations. The target analyte list of potential contaminants includes USEPA Appendix IX constituents, other constituents typically analyzed by MDEQ, and several constituents currently monitored as part of the Facility's groundwater monitoring program. Results from this SLERA will be used to:

- Provide a rational basis and documentation for retention of COPECs for further consideration;
- Provide a rational basis and documentation for exclusion of other potential contaminants from further consideration;

- Make objective decisions on whether there is the potential for unacceptable risks to the environment presented by COPECs (other than PCDDs and PCDFs) in the soils, sediments, and biota of the Site;
- Evaluate the need for further study or risk assessment for COPECs in the Site; and
- Focus future data collection to fill relevant data gaps.

1.2 Regulatory Guidance and Outline of Proposed Approach

This ERA Work Plan is based upon USEPA ERA guidance (Figure 1-1; USEPA, 1997, USEPA 1998, USEPA 1999a; USEPA, 2001a and 2001b), applicable state regulatory guidance including Part 201 of Act 451, and the conditions of the Operating License. Although not a Superfund site, the general proposed approach for this SLERA will follow USEPA ERA guidance for Superfund (USEPA, 1997) since this guidance is detailed and well accepted among ecological risk assessors. The eight step process within the USEPA ERA guidance for Superfund sites is designed to focus resources on key chemicals, pathways of exposure, and receptors and to eliminate from further consideration those chemicals, pathways, and receptors that are not at risk. The approach for this SLERA includes the following processes and data collections:

- **Pre-ERA Planning**
  - Compilation of existing information on the COPECs and receptor species at the site
  - Development of SLERA data quality objectives (DQOs)
- **SLERA**
  - Site visit - including site-specific biota inventory and habitat suitability characterization for the aquatic and terrestrial resources along the Tittabawassee River
  - Screening level problem formulation, exposure estimation, and risk characterization
  - Determine which COPECs need to be evaluated further in a more refined BERA

1.3 Schedule

Several major elements, proposed sequencing, and estimated timelines for activities related to conducting a SLERA for the Site (Figure 1-1) were identified. For a more detailed discussion of the ERA schedule and proposed ERA reports, refer to the BERA Work Plan (ENTRIX, 2005). For more details on schedule, refer to section 5.1.

1.4 Work Plan Organization

The remainder of this SLERA Work Plan is organized into the following sections and appendices:

Section 2.0. Screening-Level ERA Problem Formulation

> This section provides details concerning the problem formulation steps of a SLERA including DQOs, description of the site, and discussion of available data.

Section 3.0. Screening-Level ERA Analysis Phase – Exposure and Effects Assessment

> This section provides details concerning the various approaches that will be utilized to determine exposure, effects, and associated uncertainties.

Section 4.0. Screening-Level ERA Risk Characterization Phase

This section provides details concerning the screening-level risk characterization process.

Section 5.0. Schedule and Reporting

Section 6.0. References

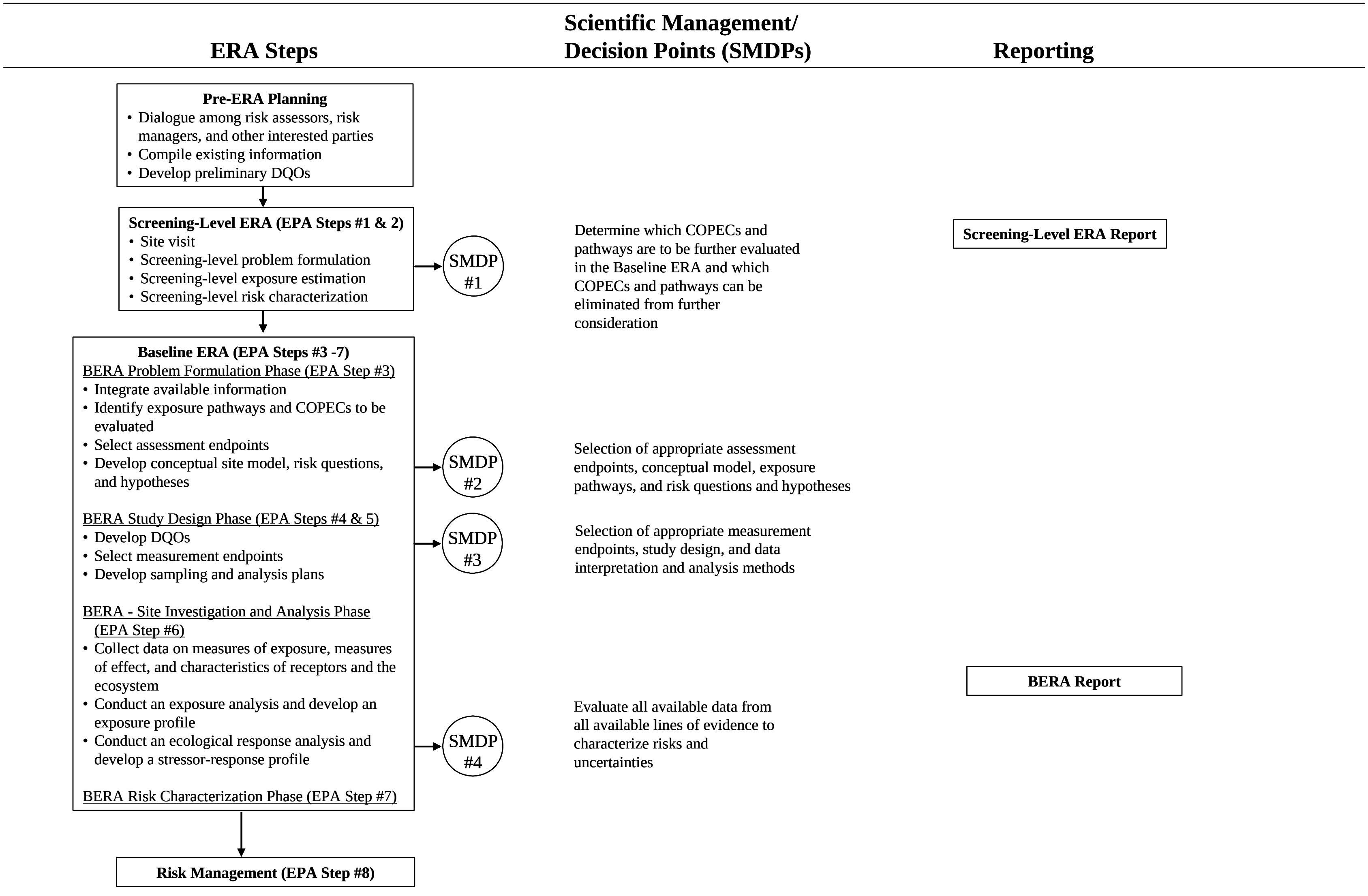


Figure 1-1. ERA steps, scientific management decision points (SMDP) and reporting (based on Superfund ERA Guidance; USEPA, 1997)

2.0 SCREENING-LEVEL ERA PROBLEM FORMULATION

In this phase of a SLERA, the study site is characterized by examining the habitat, species present, and contaminants that have been used in the vicinity. These pieces of information help to shape potential exposure pathways that will be preliminarily investigated in the SLERA. A significant purpose of the SLERA will be to identify COPECs, potential ecological receptors, and potential exposure pathways.

The SLERA will be conducted to identify and document conditions that do *not* warrant further evaluation in a more refined baseline ERA (BERA) and to identify COPECs in the Site. However, based on two previous preliminary ERAs, it is appropriate to conclude that polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) will continue to be COPECs and are currently the focus of ongoing studies that will be used in the BERA. As a result, the focus of this work plan is on identifying other potential COPECs that may be present within the Tittabawassee River and its floodplain upstream of the confluence with the Saginaw River.

2.1 Development of Screening-Level Data Quality Objectives

The DQO process is a planning tool involving a series of steps designed to ensure that the type, quantity, and quality of environmental data used for decision-making purposes are appropriate for the intended application (USEPA 2000a and 2000b). The DQO process, as defined by USEPA, is "...a strategic planning approach based on the Scientific Method that is used to prepare for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including when to collect samples, where to collect samples, the tolerable level of decision errors for study, and how many samples to collect." The steps in the DQO process, as established by USEPA, are as follows:

1. Formulation of Problem Statements. This step concisely describes the problems to be studied.

2. Identification of Decisions. This step consists of accurately describing the questions to be answered that will solve the specified problems, including any actions that may result.

3. Identification of Inputs to Decisions. This step focuses on identifying qualitative and quantitative information that will support decision-making, including the types of measurements that will be required.

4. Definition of Study Boundaries. This step delineates the spatial and temporal boundaries that will be encompassed by the study and describes when and where data shall be obtained. This includes specifying characteristics of the (statistical) population of interest, defining the geographical extent of the area and timeframes to which decisions will apply, and identifying constraints on obtaining data.

5. Development of Decision Rules. This step defines the statistical measures relevant to the study and specifies the conditions by which decision-makers will choose among alternative actions.

6. Specification of Decision Error Limits. This step specifies tolerable false positive and false negative decision errors and develops statements concerning the consequences of making incorrect decisions.

7. Optimization of Sampling Design. This step considers information obtained in the previous six steps to formulate an optimal sampling design, including (if possible) estimates of the number of samples necessary to meet acceptable decision errors.

The preliminary questions to be answered in this phase of the SLERA are:

- Is there a potential for ecological risk from contaminants in soil and sediment at this site?
- What are the COPECs in the Site that should be considered in the BERA?
- What is the spatial distribution of these COPECs?
- Which media (soil, sediment, water) contain residue of COPECs which may represent a complete exposure pathway?
- What wildlife receptor species are present in the Site that are expected to be significantly exposed to COPECs and can be used in the BERA?

A detailed DQO section, including the seven steps in the process, is presented as part of the CH2MHill Ecological Risk Assessment Support Sampling (Appendix A). For the purposes of this SLERA work plan, it is assumed that all data used in the SLERA will be of adequate quantity and quality. In addition, it is assumed that the detection limits for analytes to be evaluated in media collected from the site are sufficient such that they allow for the evaluation of potential risk when compared to the appropriate benchmarks. If after a review of the data, deficiencies are identified, then further data collection may be undertaken or other means employed to more fully characterize exposures.

2.2 Environmental Setting and Habitat Characteristics

As part of the problem formulation phase of the SLERA, a site visit will be conducted and the environmental setting of the study site will be characterized. The Site area includes sediments and floodplain soils of the Tittabawassee River downstream of Midland, Michigan. Specifically, approximately 23 miles of the Tittabawassee River from the upstream boundary of the Dow Chemical Company to the confluence of the Tittabawassee and Shiawassee Rivers downstream of Greenpoint Island (Figure 2-1). The Site includes only one dam, which is within the confines of The Dow Chemical Company property. Beyond the Dow Dam, the Tittabawassee River is free flowing to the confluence with the Saginaw River and eventually into Saginaw Bay.

The Saginaw basin is comprised of 6,260 square miles of drainage and contains urban populations in Flint, Midland, Bay City, and Saginaw. It is the largest system in Michigan. The Tittabawassee River is the main tributary of the Saginaw River, flowing from the north through Midland, Michigan in a southeastern direction to the confluence with the Saginaw River just above the City of Saginaw. The floodplains along the Tittabawassee River are periodically inundated, usually during high flows in the spring and following major storm events. In addition, releases from the Sanford dam upstream of Midland cause periodic changes in water levels and flow rates in the Tittabawassee River. Data available from 1937 to 2002 at USGS gauging station 04156000 indicate that the flows of the Tittabawassee River periodically fluctuate with high flows in the spring with occasional, short-duration periods of high flow throughout the year following substantial rain events (Figure 2-2; Figure 2-3).

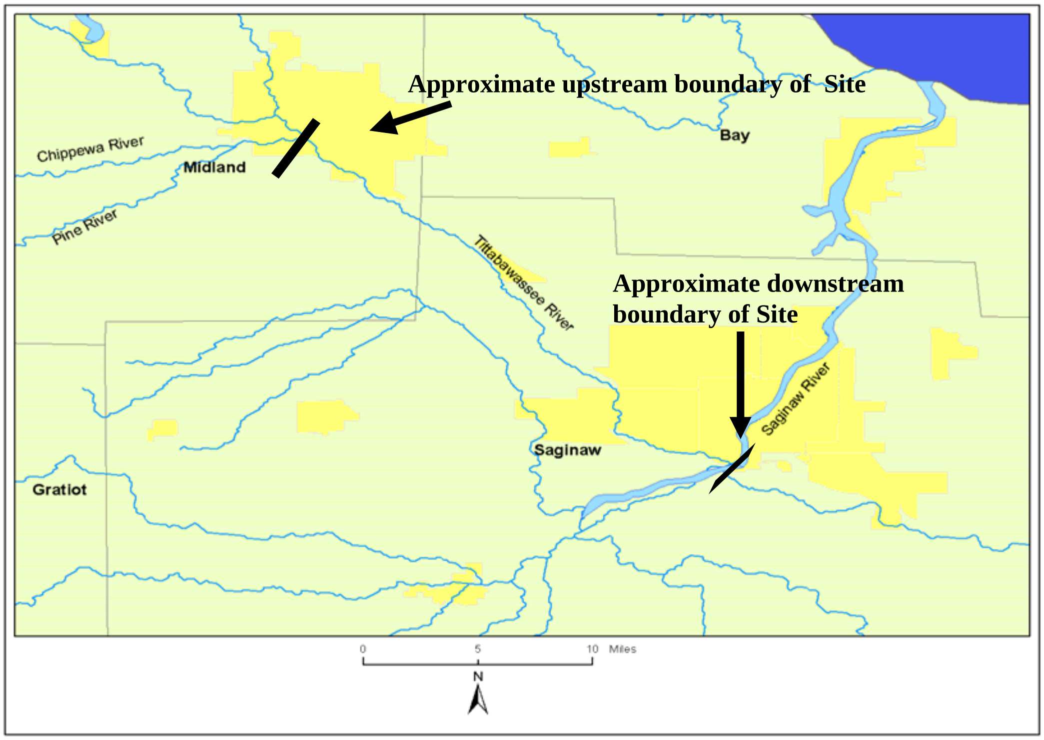


Figure 2-1. General location map showing upstream and downstream boundaries of the Site.

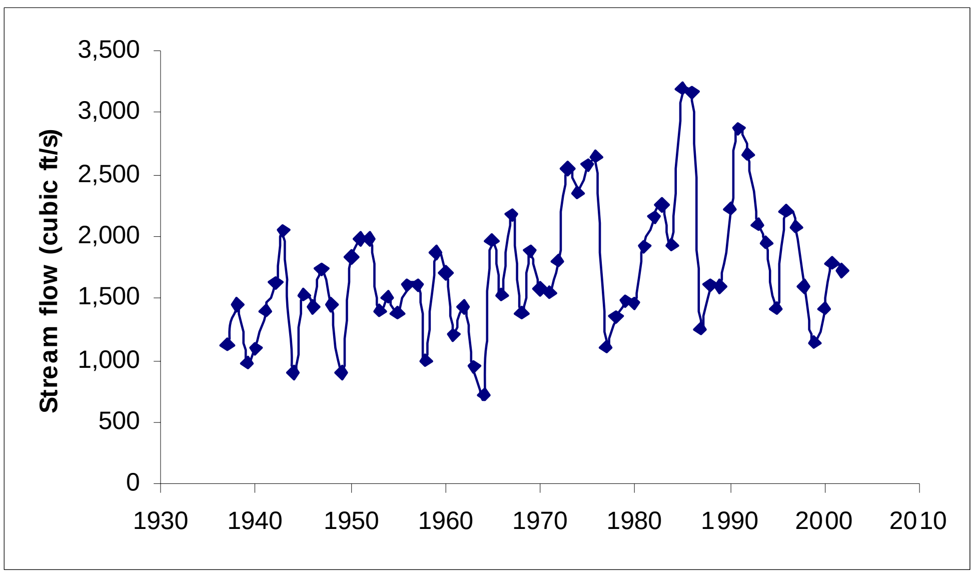


Figure 2-2. Annual stream flow on the Tittabawassee River in Midland, MI over the years 1937-2002. Data from USGS gauging station number 04156000 located on the Tittabawassee River at Midland, MI (Lat. 43 35’ 43”; Long. 84 14’ 08”) 2000 ft downstream of the Dow dam.

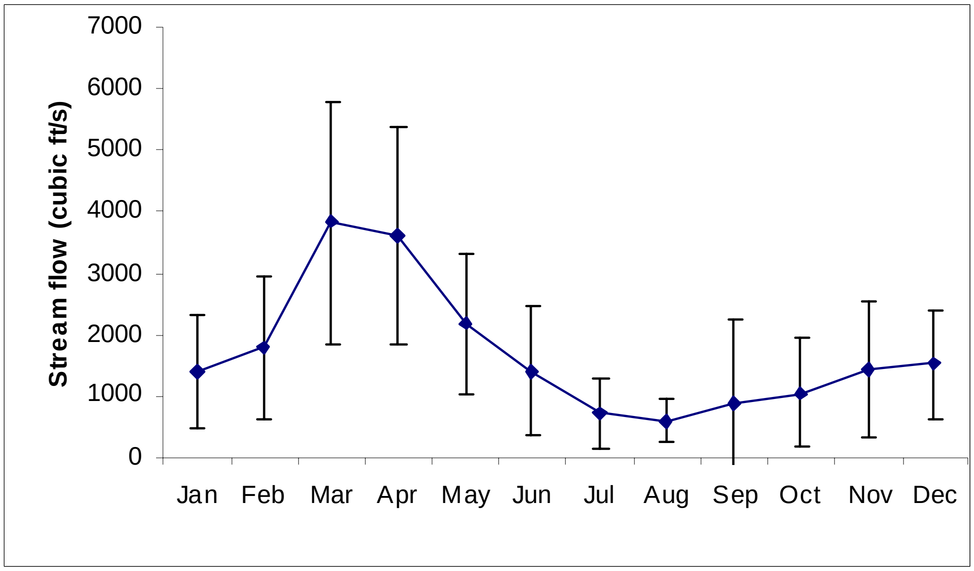


Figure 2-3. Average (± SD) monthly stream flow on the Tittabawassee River in Midland, MI over the years 1937-2002. Data from USGS gauging station number 04156000 located on the Tittabawassee River at Midland, MI (Lat. 43 35’ 43”; Long. 84 14’ 08”) 2000 ft downstream of the Dow dam.

2.3 Characteristics and Definitions of Sediment and Floodplain Soil

Sediments and soils are typically very distinct from each other based, in part, on differences in physical characteristics, functions, and influences on fate, transport and exposure pathways for COPECs. However, for a floodplain, in which the site is periodically inundated and then not covered with water for substantial amounts of time each year, the distinctions between sediments and soils are less clear. Since chemical fate, transport, and availability are significantly different between floodplain or wetland soils and true sediments, it is important to have a working definition to differentiate between these two matrices. For the purposes of this SLERA Work Plan, sediments at this site are defined as those portions of the site that are permanently flooded or are flooded for most of the time with little to no emergent vegetation present. This is consistent with USEPA guidance, which considers the regularity, depth, and duration of flooding as well as the presence or absence of emergent vegetation in making the determination. If soils are flooded enough to qualify as sediments and are not vegetated with emergent species, then Ecological Soil Screening Levels (Eco-SSLs) should not be used (USEPA, 2005).

2.4 Contaminants Known or Suspected to be at the Site

Historical information of the site under investigation is an important consideration when attempting to identify chemicals of potential ecological concern (COPECs) in environmental media.

2.4.1 Historical Data Sources

Several historical data sources have been identified to date. Data from these sources will be incorporated in the SLERA analysis. A list of reference studies, including those cited below, is provided (Table 2-1). This list will likely expand as studies are identified or as new data become available.

Dow, Michigan Department of Natural Resources (MDNR), Michigan Department of Environmental Quality (MDEQ), and other agencies and parties have conducted activities to evaluate the environmental quality of the Tittabawassee River since the 1960's. Work to date has been conducted as independent studies and in conjunction with conditions in Dow's operating permits (e.g. NPDES, Hazardous Waste Operating License). Environmental studies starting in the 1960s and 1970s focused on macroinvertebrate populations in the river sediments, general water quality, and fish mortality rates. PCDD and PCDF measurement in fish began in the mid-1970s. Baseline type studies were conducted in the early to mid-1980s in conjunction with the NPDES-permitting process. Water column and sediment sampling were conducted in 1981. A wastewater characterization study was conducted in 1986 that reviewed, both fish and wastewater-related data from the previous 8 years. Three regional studies published in 1988, 1993, and 1994 provide corresponding information on the drainage area in terms of topography, hydrology, land uses, soil types, and transport of solids under various flow conditions. River sediments were first sampled by USEPA in 1981 with subsequent sediment and floodplain soil samples collected in 1984 to expand the analytical suite to include polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and other chlorinated hydrocarbons. In 1996, MDEQ collected and analyzed a number of surface soil, river plain, and river sediment samples. Additional samples collected in 2000 as part of a MDNR wetland mitigation project segued into MDEQ investigations, including a Phase I floodplain soil study (MDEQ, 2001), a baseline sediment study (MDEQ, 2002), a Phase II floodplain soil study (MDEQ, 2003), and a residential floodplain soil sampling study (MDEQ, 2004). These four MDEQ studies have produced the greatest volume of Tittabawassee River sediment and floodplain soil data to date. In particular, the Baseline Chemical Characterization Study (MDEQ, 2002) analyzed soil and sediment samples for a wide range of volatile and semi-volatile organic compounds (e.g., VOCs and sVOCs), pesticides, polychlorinated biphenyls (PCBs), polybrominated biphenyls (PBBs), and metals. Another source of data is the Michigan Fish Contaminant Monitoring Program (FCMP), conducted by MDEQ. The FCMP includes data from areas upstream and downstream of Midland for caged catfish, skin-on and skin-off fillets for a variety of native fish species, and native whole fish samples (MDEQ, 2005). The analyte list for the FCMP varies by year and location, but generally includes mercury, PCBs, PCDDs, PCDFs, and organochlorines.

Table 2-1. Historical data sources for studies conducted in the area of concern

Matrix Analyzed for Contaminants	Agency or Author	Year	Title
Sediments	Rossman et al. (USEPA)	1983	The impact of pollutants on the Tittabawassee River
Sediments and fish	Amendola et al. (USEPA)	1986	Dow Chemical wastewater characterization study: Tittabawassee River sediments and native fish.
Fish	USEPA Region V	1988	Proposed risk management actions for dioxin contamination at Midland, Michigan
Water quality	Michigan DNR	1988	Saginaw River and Saginaw Bay area of concern remedial action plan
Suspended soils	Jude et al. (University of Michigan)	1993	Suspended solids and bedload transport of nutrients, heavy metals, and PCBs in 16 major tributaries to Saginaw Bay, 1990 – 1992
Sediments	University of California, Santa Barbara	1994	The transport of sediments and contaminants in the Lower Saginaw River
Semi-permeable membrane devices, sediments, and fish	Gale et al.	1997	Comparison of the uptake of dioxin-like compounds by caged channel catfish and semi-permeable membrane devices in the Saginaw River, Michigan
Soil	Michigan DEQ	2001	Phase I Tittabawassee/Saginaw River dioxin floodplain sampling study
Soil and sediment	Michigan DEQ	2002	Baseline chemical characterization of Saginaw Bay watershed sediments
Soil	Michigan DEQ	2003	Final report. Phase II Tittabawassee/Saginaw River dioxin floodplain sampling study
Fish and some bird eggs	Michigan DEQ (prepared by Galbraith Environmental Sciences)	2003	Tittabawassee River aquatic ecological risk assessment: polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans
Fish	Michigan DEQ	1980-2003	Michigan Fish Contaminant Monitoring Program
Soil, sediment, plants, invertebrates, earthworms	MSU/ENTRIX	2004	Concentrations of PCDDs and PCDFs in Soils, Sediments, and Biota from the Aquatic and Terrestrial Food Webs of the Tittabawassee River (Data from Fall 2003)
Deer, turkeys, and squirrels	ENTRIX/Dow Chemical	2004	Evaluation of PCDDs and PCDFs in the wild game taken from the floodplain along the Tittabawassee River
Soil	Michigan DEQ	2004	Preliminary analytical results for soil samples taken at residential properties in the Tittabawassee River floodplain by the MDEQ in June through December of 2003

2.4.2 ERA-Related Activities

Although data have been collected for several decades, there have been no comprehensive ecological evaluations of the entire study area for chemicals other than PCDDs and PCDFs. This SLERA Work Plan is designed to build upon currently available data. Such data are available from studies conducted through MDEQ investigations, Michigan State University (MSU), Dow, ENTRIX, CH2MHILL, USFWS, and others (Table 2-1).

2.5 Species Present or Potentially Present at the Site

Based on a preliminary review of existing data, the Site provides habitat for a wide variety of vegetation, invertebrates, fish, birds, mammals, and amphibians and reptiles. An estimated total of more than 380 species, including birds (>260), mammals (>30), reptiles and amphibians (>20), and fish (>70), potentially inhabit the Tittabawassee River and floodplain (USFWS, 2001). Species expected to be most common in the floodplain include tree swallow (*Tachycineta bicolor*), barn swallow (*Hirundo rustica*), bank swallow (*Riparia riparia*), American crow (*Corvus brachyrhynchos*), American robin (*Turdus migratorius*), European starling (*Sturnus vulgaris*), red-winged blackbird (*Agelaius phoeniceus*), common grackle (*Quiscalus quiscula*), mallard (*Anas platyrhynchos*), muskrat (*Ondatra zibethica*), meadow vole (*Microtus pennsylvanicus*), raccoon (*Procyon lotor*), green frog (*Rana clamitans*), northern leopard frog (*Rana pipiens*), and common garter snake (*Thamnophis sirtalis*). Other notable species that have been observed include bald eagle (*Haliaeetus leucocephalus*), osprey (*Pandior haliaetus*), great blue heron (*Ardea herodias*), black-crowned night-heron (*Nycticorax nycticorax*), belted kingfisher (*Ceryle alcyon*), great horned owl (*Bubo virginianus*), red-tailed hawk (*Buteo jamaicensis*), red fox (*Vulpes vulpes*), mink (*Mustela vison*), and short-tailed shrews (*Blarina brevicauda*).

3.0 SCREENING LEVEL ERA ANALYSIS PHASE – EXPOSURE AND EFFECTS ASSESSMENT

During the analysis phase, exposure to stressors and the relationship between stressor concentrations and ecological effects are evaluated. Maximum concentrations in environmental media (water, sediment, soil) are the exposure estimates that will be compared to corresponding media specific conservative effects benchmarks in the screening level ERA approach described in this work plan. In the case where a benchmark is unavailable for a detected compound or the case where a compound is determined to have sufficient potential to be persistent and bioaccumulative, it may be necessary to generate estimates of exposure and or effects for receptors of interest as described in the following sections.

3.1 Screening Level Estimates of Exposure

For most COPECs, exposure to receptors will not be calculated during the SLERA, rather the maximum concentration in a media will be compared to an appropriate screening level benchmark (discussed later). However, for some COPECs, the exposure pathways for ecological receptors (e.g., plants and animals) may be considered based on the absence of suitable media specific conservative benchmarks. In order to estimate exposures in cases when site-specific information is lacking, conservative exposure assumptions are made in order to minimize the chance of concluding there is no risk when risk may exist. These conservative assumptions include (1) ecological receptors are present within the contaminated area 100% of the time, (2) contaminants at the site are 100% bioavailable to biota, (3) the most sensitive life stage of the organism is being exposed to contaminants, and (4) the species in question feeds entirely upon the most contaminated food source. In addition to these assumptions, estimates of bioaccumulation, body weight, and ingestion rates are made in a conservative fashion in order to estimate exposure.

Exposure point concentrations of COPECs will be determined and compared to toxicity reference values in order to calculate the potential for adverse effects. In general, there are two primary approaches, dietary-based and receptor tissue-based, for assessing exposure and effects of persistent, bioaccumulative COPECs in wildlife assessments (Fairbrother, 2003). Each of these approaches is discussed in the following sections.

3.1.1 Dietary Exposure Modeling Approach

The dietary-based method is one of the most widely used approaches to assess wildlife exposure, ranging from simplistic to complex. In general, an average daily dose is calculated by food web modeling in which one makes assumptions regarding dietary composition, applies bioaccumulation models (if necessary), and utilizes concentrations of residues measured at lower levels of the food chain, soil, and sediment. In a SLERA, this can be based on very limited data and in many cases is based on default assumptions regarding dietary preferences, food ingestion rates and other biological parameters. The exposure that is calculated from this dietary exposure-based approach can then be compared to dietary-based toxicity reference values (TRVs) derived from dietary exposures.

3.1.1.1 Exposure Characteristics of Avian and Mammalian Wildlife Receptors

When it is necessary to identify receptors for an exposure analysis, characteristics of key receptors will be presented in the SLERA, including exposure assumptions for body weight, ingestion rate, dietary composition, area use factor, etc. Exposure analyses will be conducted with receptor species selected from specific foraging guilds. Examples of possible foraging guilds that could be utilized in the SLERA include mammalian herbivores, omnivores, and carnivores and avian granivores, insectivores, vermivores, omnivores and carnivores. The selected species within these foraging guilds are those species that demonstrate high exposure tendencies relative to their exposure to sediments and/or soils since these media often serve as primary reservoirs of chemical contamination. The primary source of exposure assumptions is the USEPA Exposure Factors Handbook (USEPA, 1993). Additional sources of information include primary peer-reviewed scientific literature, site surveys, and professional judgment, and other compendia of region-specific and species-specific information (Sample and Suter, 1994). Whenever available, site-specific and/or region-specific exposure information will be utilized. The selected species might be exposed to COPECs through contact with and/or ingestion of contaminated media (e.g., primarily through dietary exposure). Exposure estimates for all species will be calculated for COPECs detected in dietary items and incidental soil ingestion.

Exposure calculations will be conducted with exposure concentrations derived from either measured concentrations of chemical stressors or concentrations predicted from models in the case when no measured concentrations are available. Bioaccumulation models are often fraught with uncertainty because bioavailability depends upon highly variable site-specific considerations such as soil type, pH, moisture, clay content, organic carbon, cation exchange capacity, and receptor-specific considerations such as uptake mechanisms. In particular, available information suggests very limited assimilation and accumulation of particulate-bound COPECs into vegetation, invertebrates, and small mammals (ENTRIX 2004b).

3.1.1.2 Estimation of Oral Exposure for Avian and Mammalian Wildlife Receptors

Estimates of daily contaminant exposure experienced by individual receptor species are calculated using a modification of the generalized exposure model presented by Sample and Suter (1994). The generalized exposure model is depicted (Eq. 3-1):

$$ADD_{pot} = \frac{[(IR_{diet} \, x \, C_{diet}) + (IR_{soil} \, x \, C_{soil}) + (IR_{sed} \, x C_{sed})] x \; SUF}{BW} \qquad \textbf{Eq. 3-1}$$

Where:

ADD_{pot} = potential average daily dose (*e.g.*, mg/kg-d)

IR_{diet} = Amount of prey or vegetation ingested (kg/d)

C_{diet} = Concentration of chemical in prey or vegetation (mg/kg)

IR_{soil} = Amount of soil ingested (kg/d)

C_{soil} = Concentration of chemical in soil (mg/kg)

IR_{sed} = Amount of sediment ingested (kg/d)

C_{sed} = Concentration of chemical in sediment (mg/kg)

SUF = Site use factor (unitless) (foraging area/site area)

BW = Body weight (kg)

As stated previously, area use factor will be assumed to be 100% during the SLERA even though some species may forage in only a portion of the site and/or there may be limitations on the availability of suitable habitat for a given receptor. In addition, bioavailability will be assumed to be 100% during the SLERA. Fractional absorption for all compounds from the diet via the gut will be assumed to be 100%.

The resulting ADD_{pot} is also termed the estimated environmental concentration (EEC) since the ADD_{pot} is a rough estimate of exposure based on conservative assumptions. This fractional absorption factor is especially important for incidental ingestion of sediments and soils. It has been shown that sorption of COPECs to soil may substantially reduce its bioavailability.

3.1.2 Receptor Tissue Exposure Approach

When appropriate and in addition to the dietary-based approach, exposure to some receptors for some COPECs may be evaluated based on tissue residue concentrations. For the SLERA, depending on the availability of concentration data, one of two different approaches will be used in this analysis. First, if tissue residue data are available for a specific receptor (e.g. egg, fish tissue, etc), these data will be compared to appropriate benchmark values or toxicity reference values (TRVs). The second approach will use media specific concentration data (e.g. water, sediment, soil) that has been modeled up into receptors of concern using literature-based bioaccumulation factors (Sample et al. 1998).

3.2 Screening Level Ecological Effects Assessment

The purpose of the effects assessment phase is to summarize available toxicological data, establish toxicity reference values (TRVs) and benchmarks for COPECs for the SLERA, and present ecologically relevant field observations. Screening level benchmark values are chemical specific and can be either media specific (e.g. soil, sediment, water) or dose-specific (e.g. TRVs based on dietary exposure or tissue residue concentrations). In the absence of conservative media-specific screening benchmarks, the availability of both dietary exposure and tissue residue-based toxicological data will be evaluated for COPECs as needed and the limitations of these toxicity data discussed. This information will be utilized with exposure data to conduct the risk characterization (Section 4.0).

3.2.1 Screening Level Ecological Benchmarks

In this step of the screening-level ERA, the risk assessor determines, from a review of the scientific literature, the toxicity benchmark values that are protective of plants and animals present at the study site. It is important to note that these benchmarks are for screening purposes only and do not represent remedial action cleanup levels. For media specific evaluations, the USEPA Region 5 RCRA ecological screening level benchmarks will be used as the default (USEPA 2003). However the list of potentially applicable or suitably analogous toxicity benchmarks that will be evaluated in the circumstance that a default benchmark is unavailable or otherwise inappropriate, such as for persistent bioaccumulative compounds, includes:

- Michigan Water Quality Standards: Rule 57;
- Consensus based threshold effects concentrations (TEC) (MacDonald et. al.2000)
- USEPA National Recommended Water Quality Criteria (USEPA, 1999b);
- USEPA Region IV Ecological Screening Values (USEPA Region IV, 2004);
- Oak Ridge National Laboratory Ecotoxicological Screening Benchmark Reports;
- Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota (Suter and Tsao, 1996)
- Ecological Soil Screening Levels (Eco-SSLs; USEPA, 2005);
- Concentrations reported in the scientific literature to be associated, or potentially associated, with toxic effects.

For dose-specific evaluations, the list of potentially applicable or suitably analogous toxicity benchmarks that will be evaluated include:

- Toxicological Benchmarks for Wildlife: 1996 Revision (Sample et al. 1996)
- Wildlife Toxicity Assessment Series (USACHPPM 2000)

3.2.2 Development of Toxicity Reference Values (TRVs)

When chemical-specific toxicological benchmarks are not available for wildlife receptors of concern, toxicity reference values (TRVs) will be derived from literature data. A toxicity reference value (TRV) is a concentration of a chemical in water, food, or tissues of a receptor below which toxicological effects are not expected. Ideally, toxicity reference values are derived from chronic toxicity studies in which a dose-response relationship has been observed for ecologically-relevant endpoint(s) in the species of concern, or a closely related species. Specifically, some of the ideal characteristics of high quality toxicity studies that can be used to derive TRVs include:

1. Relatedness of the test species to the receptor of concern;
2. Chronic duration of exposure including sensitive life stages to evaluate potential developmental and reproductive effects;
3. Measurement of ecologically relevant endpoints; and
4. Minimal impact of co-contaminants.

It is essential to perform a critical evaluation of the applicability of the toxicological data to the site-specific receptors of concern and exposure pathways. TRVs derived in the same species are generally not available for the majority of wildlife receptors and, therefore, it is necessary to derive TRVs using toxicological data for surrogate species in combination with uncertainty factors. Uncertainty concerning interpretation of the toxicity test information among different species, different laboratory endpoints, and differences in experimental design, age of test animals, duration of test, etc., are addressed by applying uncertainty factors (UFs) to the toxicology data to derive the final TRV. In general, two approaches are used to estimate UFs, the modeled factor approach and the safety factor approach (Duke and Taggart, 2000). UFs used in the modeled approach are predictive while those used in the safety factor approach are protective. For this SLERA, the safety factor approach will be used to derive TRVs in that it treats all extrapolations in a conservative manner and reflects the amount of uncertainty in the extrapolations. Two methodologies will be evaluated relative to selecting uncertainty factors, the procedures set out in the Great Lakes Initiative (GLI: USEPA 1995) and the procedures outlined in the standard practice for wildlife TRVs from the USACHPPM (USACHPPM 2000).

4.0 SCREENING-LEVEL ERA RISK CHARACTERIZATION PHASE

This section presents approaches for identifying COPECs and characterizing risk.

4.1 Screening Level Risk Calculation

By using maximum concentrations in the environmental media (water, sediment or soil) and the lowest possible screening benchmarks, the SLERA is designed to minimize chances of eliminating a COPEC from further consideration when it may pose an actual ecological risk. Thus, the resulting risk calculation is expected to be an overestimate of actual risk and can not be used to derive remedial action cleanup levels (USEPA, 1997). From the available data, potential ecological risks can be estimated based upon a series of calculated hazard quotients (HQs). In short, a HQ is calculated by dividing the estimated exposure dose or estimated environmental concentration (EEC) by a toxicity benchmark for each receptor (Eq. 4-1, Eq. 4-2).

$$HQ = \frac{\text{Dose}}{\text{Toxicity Benchmark}} \qquad \textbf{Eq. 4-1}$$

$$HQ = \frac{\text{EEC}}{\text{Toxicity Benchmark}} \qquad \textbf{Eq. 4-2}$$

If the HQ $\geq$ 1.0, the exposure pathway will be further evaluated in the BERA. If the HQ < 1.0, this indicates that harmful effects are not likely and the exposure pathway can be eliminated from further BERA investigations. For COPECs that are retained for further evaluation, exposure pathways will be evaluated to determine which potentially significant exposure pathways require further evaluation. For example, available data may indicate that a COPEC is below an ecological screening benchmark in one medium but exceeds an ecological screening benchmark for another medium. This evaluation will help focus resources to evaluate only those COPECs and exposure pathway combinations that exceed ecological screening benchmarks.

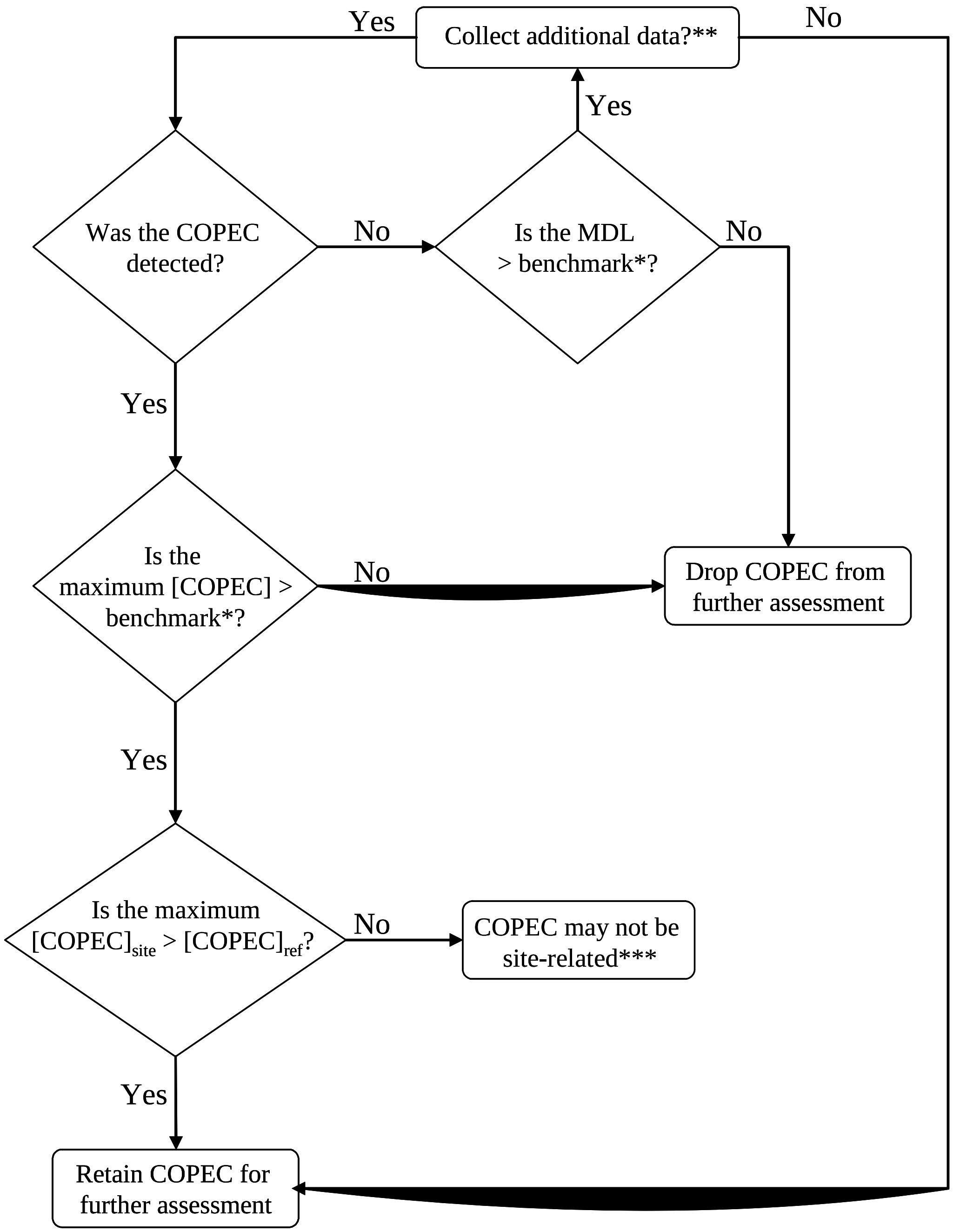
COPECs will be assessed by using measured concentrations on the Site. COPECs will be evaluated by one or more of the following approaches:

(1) Compare maximum concentrations in the environmental media (water, sediment, and soil) to corresponding media-specific conservative benchmarks;

(2) If necessary, compare estimated exposure doses to toxicity reference values for select receptors of concern;

(3) Compare media-specific concentrations to background to determine potential non-site-related concentrations of COPECs (both natural and anthropogenic).

A decision tree for determining which COPECs are to be retained or dropped for further assessment will be followed (Figure 4-1). COPECs that exceed the ecological screening benchmarks or reported toxic doses will be carried forward into the BERA for further evaluation unless it is determined that the COPEC concentration at the site ($[\text{COPEC}]_{site}$) is less than the COPEC concentration at the reference area ($[\text{COPEC}]_{ref}$) or is otherwise consistent with background levels. Based on historical data, it is assumed that polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) will be retained as COPECs beyond the SLERA and are the main focus of the BERA Work Plan.



* If benchmark is not available, attempts will be made to develop benchmark for COPEC &/or consider other factors, which may include exposure modeling

** May include re-analysis of sample with lower MDL or collection of new sample(s)

*** This most commonly occurs with naturally occurring inorganic constituents, but may occur with any COPEC for which additional non-site-related sources are present

Figure 4-1. Decision tree for screening COPECs.

4.2 Uncertainty in the Screening Level ERA

Since a SLERA is deliberately designed to be protective in nature, not predictive of effects, it follows that there is a considerable amount of uncertainty associated with results from a SLERA. Thus, to ascertain the confidence placed upon the SLERA, the potential sources of uncertainty will be evaluated within the context of the site. For instance, assumptions made in estimating exposure for specific receptors will be identified and the magnitude and direction of the bias associated with each assumption will be described. For example, the exposure assumptions of 100% presence on a contaminated site may not be true for many species. Likewise, the assumption of 100% contaminant bioavailability may not be true for COPECs that are tightly bound to soils and sediments. Other sources of uncertainty to be addressed include the limitations of the data relative to understanding the spatial extent and representativeness of the samples relative to characterizing the site, uncertainty in regards to data analysis techniques, data availability, appropriateness of selected media specific benchmarks or TRVs and exposure model parameters, as well as the use of surrogate species data evaluate the potential risk to specific receptors found at the site. In addition, uncertainty and relative degree of overestimation or underestimation of exposure and effect will be examined and discussed when evaluating the results of the SLERA.

4.3 Scientific Management Decision Point #1

Based on the SLERA, decisions can be made to determine which COPECs and pathways are to be further evaluated in the BERA *and* which COPECs and pathways can be eliminated from further consideration. Following the SLERA, decisions will be made in consultation with MDEQ based on the determination of potential ecological risks. Thus, three possible decisions can be reached following the SLERA:

- There is enough information to conclude that ecological risks are low or non-existent and there is no need to clean up the site on the basis of ecological risk,
- There is not enough information to make a decision and the ERA will proceed, or
- The information indicates a potential for adverse ecological effects, and a higher tiered BERA is required.

5.0 SCHEDULE AND REPORTING

5.1 Schedule

Once MDEQ provides comments on the draft SLERA work plan, Dow and ENTRIX will respond to comments and prepare a revised SLERA work plan within 60 days. Following approval of the SLERA workplan and once consensus has been reached for scientific management decision point (SMDP) #1 (section 4.3), Dow and ENTRIX will submit a schedule for the preparation of a draft SLERA report within 30 days. Once MDEQ provides comments on the draft SLERA report, Dow and ENTRIX will respond to comments and prepare a revised SLERA report within 60 days.

5.2 Reporting

If any major deviations from the approved Work Plan are necessary because of unanticipated field conditions, the MDEQ will be notified as soon as possible for approval and modification of the Work Plan, if needed. In addition, bimonthly progress reports will be provided to MDEQ beginning after approval of this Work Plan.

Reports from this project will include data obtained from the field and laboratory phases of the study. At the termination of the study, MDEQ will be provided with an electronic copy of both laboratory and field data packages.

6.0 REFERENCES

Amendola, G.A., Barna, D.R. 1986. Dow Chemical Wastewater Characterization Study: Tittabawassee River Sediments and Native Fish. (EPA, Michigan Dioxin Studies).

ENTRIX 2004a. Evaluation of PCDDs and PCDFs in Wild Game Taken from the Floodplain Along the Tittabawassee River.

ENTRIX 2004b. Concentrations of PCDDs and PCDFs in Soils, Sediments, and Biota from the Aquatic and Terrestrial Food Webs of the Tittabawassee River: Round 1 (Fall 2003).

ENTRIX 2005 Draft Baseline Ecological Risk Assessment Work Plan for Polychlorinated –p-dioxins (PCDDs) and Dibenzofurans (PCDFs) in the Tittabawassee River and Associated Floodplains.

Fairbrother, A. 2003. Lines of Evidence in Wildlife Risk Assessments. *Human Ecol. Risk Assess*. October. 9 (6): 1475-1491.

Galbraith Environmental Sciences (GES)/MDEQ 2003. Tittabawassee River Aquatic Ecological Risk Assessment: polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans. October, 2003.

Gale, R.W., Huckins, J.N., Petty, J.D., Peterman, P.H., Williams, L.L., Morse, D., Schwartz, T.R., Tillitt, D.E. 1997. Comparison of the uptake of dioxin-like compounds by caged channel catfish and semipermeable membrane devices in the Saginaw River, Michigan. *Environ Sci & Toxicol* 31: 178-187.

Jude, D.J., Francis, D., Barres, J., Deboe, S. 1993. Suspended Solids and Bedload Transport of Nutrients, Heavy Metals, and PCBs in 16 Major Tributaries to Saginaw Bay, 1990 – 1992. October

MacDonald, D.D., Ingersoll, C.G., Berger, T.A. 2000. Development and evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems. *Arch Environ Contam Toxicol* 39:20-31.

MDEQ 2001. Phase I Tittabawassee/Saginaw River Dioxin Floodplain Sampling Study. October.

MDEQ 2002. Baseline Chemical Characterization of Saginaw Bay Watershed Sediments – A report to the Office of the Great Lakes, Michigan Department of Environmental Quality. August 29.

MDEQ 2003. Final Report. Phase II Tittabawassee/Saginaw River Dioxin Floodplain Sampling Study. June.

MDEQ 2004. Preliminary Analytical Results for Soil Samples taken at Residential Properties in the Tittabawassee River Floodplain by the DEQ in June through December of 2003. Michigan Department of Environmental Quality. February 23.

MDEQ 2005. Michigan Fish Contaminant Monitoring Program. Available on-line at: http://www.deq.state.mi.us/fcmp/

Michigan DNR. 1988. Saginaw River and Saginaw Bay Area of Concern Remedial Action Plan. September.

Rossman, R., Rice, C.P., and Simmons, M.S. 1983. The Impact of Pollutants on the Tittabawassee River.

Sample, B.E., Opresko, D.M., Suter, G.W. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Health Sciences Research Division, Oak Ridge National Laboratory, ES/ER/TM-86/R3.

Sample, B.E., and Suter, G.W.II 1994. Estimating exposure of terrestrial wildlife to contaminants. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-125.

Suter, G.W.II., Tsao, C.L., Risk Assessment Program. 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision Prepared For: U.S. Dept. of Energy, Office of Environmental Management; S/ER/TM-96/R2.

University of Santa Barbara 1994. The Transport of Sediments and Contaminants in the Lower Saginaw River. Mary Cardenas Ph.D. Dissertation.

USACHPPM 2000. Standard Practice for Wildlife Toxicity Reference Values. Environmental Health Risk Assessment Program. Technical Guide No. 254, Aberdeen Proving Ground, MD.

USEPA Region V. 1988. Proposed Risk Management Actions for Dioxin Contamination at Midland, Michigan. April 14.

USEPA 1993. Wildlife Exposure Factors Handbook Vol. I of II. U.S. Environmental Protection Agency, Office of Research and Development. Washington, D.C. EPA/600/R-93/187a. December.

USEPA 1994. Standard Operating Procedures 2004; Sample Packaging and Shipment - EPA/REAC. U.S. Environmental Protection Agency, Washington, DC. U.S. EPA Contract 68-C4-0022. August 11.

USEPA, 1995. Final water quality guidance for the Great Lakes. Fed. Register 60(56): 15366-15425.

USEPA 1996. ECO Update - Ecotox Thresholds. EPA 540-F-95-038.

USEPA 1997. Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments. EPA 540-R-97-006.

USEPA 1998. Guidelines for Ecological Risk Assessment. EPA/630/R-95/002F.

USEPA. 1999a. Issuance of Final Guidance: Ecological Risk Assessment and Risk Management Principles for Superfund Sites . OSWER Directive 9285.7-28 P.

USEPA 1999b. National Recommended Water Quality Criteria-Correction. EPA 822-Z-99-001: 1-25

USEPA 2000a. Guidance for the Data Quality Objectives Process; EPA QA/G-4. Washington, D.C.: 600/R-96/055.

USEPA 2000b. Data Quality Objectives Process for Hazardous Waste Site Investigations; EPA QA/G-4HW. Washington, D.C.: 600/R-00/007.

USEPA 2001a. ECO Update, The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments, OSWER 9345.0-14.

USEPA 2001b. Risk Assessment Guidance for Superfund: Volume III - Part A, Process for Conducting Probabilistic Risk Assessment, EPA 540-R-02-002, OSWER 9285.7-45.

USEPA 2003. Region 5 RCRA Ecological Screening Levels. http://www.epa.gov/reg5rcra/ca/edql.htm

USEPA 2004. Region 4 Ecological Risk Assessment Bulletins - Supplement to RAGS. 2004. http://www.epa.gov/region4/waste/ots/ecolbul.htm

USEPA 2005. Guidance for Developing Ecological Soil Screening Level. Washington, D. C. OSWER Directive 9285.7-55. http://www.epa.gov/ecotox/ecossl/pdf/ecossl_guidance_chapters.pdf

USFWS 2001. Shiawassee National Wildlife Refuge Comprehensive Conservation Plan and Environmental Assessment. http://www.fws.gov/midwest/planning/Shiawassee/index.html#summaryCCP

Appendix A. CH2MHill 2005 Ecological Risk Assessment Support Sampling